# Tunable Optical Assembly With Vibration Dampening

## Flat actuators are mechanically simple and offer vibration dampening.

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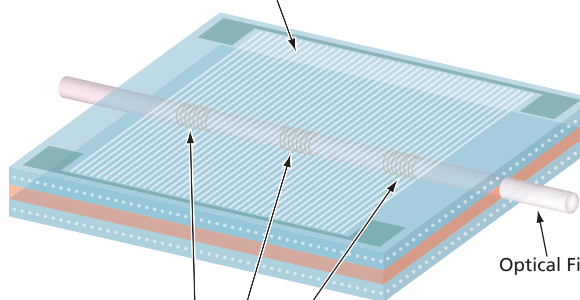
Since their market introduction in 1995, fiber Bragg gratings (FBGs) [wherein "fiber" signifies optical fiber] have emerged as excellent means of measuring such parameters as strain and temperature. Distributed-grating sensing is particularly beneficial for such structural-health monitoring applications such as those of "smart" structures or integrated vehicle health management in aerospace vehicles. Because of the variability of their output wavelengths, tunable lasers have become widely used as means of measuring FBGs.

Several versions of a lightweight assembly for strain-tuning an FBG and dampening its vibrations have been constructed. The main components of such an assembly are one or more piezoelectric actuators, an optical fiber containing one or more Bragg grating(s), a Bragg-grating strain-measurement system, and a voltage source for actuation. The piezoelectric actuators are, more specifically, piezoceramic fiber composite actuators and, can be, still more specifically, of a type known in the art as macro-fiber composite (MFC) actuators. In fabrication of one version of the assembly, the optical fiber containing the Bragg grating(s) is sandwiched between the piezoelectric actuators (see figure) along with an epoxy that is used to bond the optical fiber to both actuators, then the assembly is placed in a vacuum bag and kept there until the epoxy is cured.




**In This Tunable Optical Assembly,** an optical fiber containing Bragg gratings is sandwiched between two MFC actuators.

Two other versions of the assembly can be characterized as follows:

- During the fabrication of one of the piezoelectric actuators, the optical fiber containing the Bragg grating(s) is embedded in the actuator in place of one of the piezoceramic fibers.
- The surface of an MFC actuator is roughened by sandblasting to improve subsequent bonding, then the optical fiber containing the Bragg grating(s) is bonded to the roughened surface by use of an adhesive.

In operation of any version of the assembly, when the optical fiber is strained by the actuator(s), the wavelength of light reflected from the Bragg grating(s) changes by an amount that depends on the amount of strain. This method of straining an optical fiber containing Bragg gratings to produce a shift in the reflected wavelength holds promise because it may also be useful for tuning an optical-fiber laser.

Bonding an FBG directly into an MFC actuator greatly reduces the complexity, relative to assemblies, of the type described in the immediately preceding article, that include piezoceramic fiber composite actuators, hinges, ferrules, and clamp blocks with setscrews. Unlike the curved actuators, MFC actuators are used in a flat configuration and are less bulky than are the assemblies described in the immediately preceding article. In addition, the MFC offers some vibration dampening and support for the optical fiber whereas, in an assembly of the type described in the immediately preceding article, the optical fiber is exposed, and there is nothing to keep the exposed portion from vibrating.

*This work was done by Qamar A. Shams, Sidney G. Allison, and Robert L. Fox of Langley Research Center. Further information is contained in a TSP (see page 1).*
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# Passive Porous Treatment for Reducing Flap Side-Edge Noise

## Advantages include broadband noise reduction with no aerodynamic-lift penalty.

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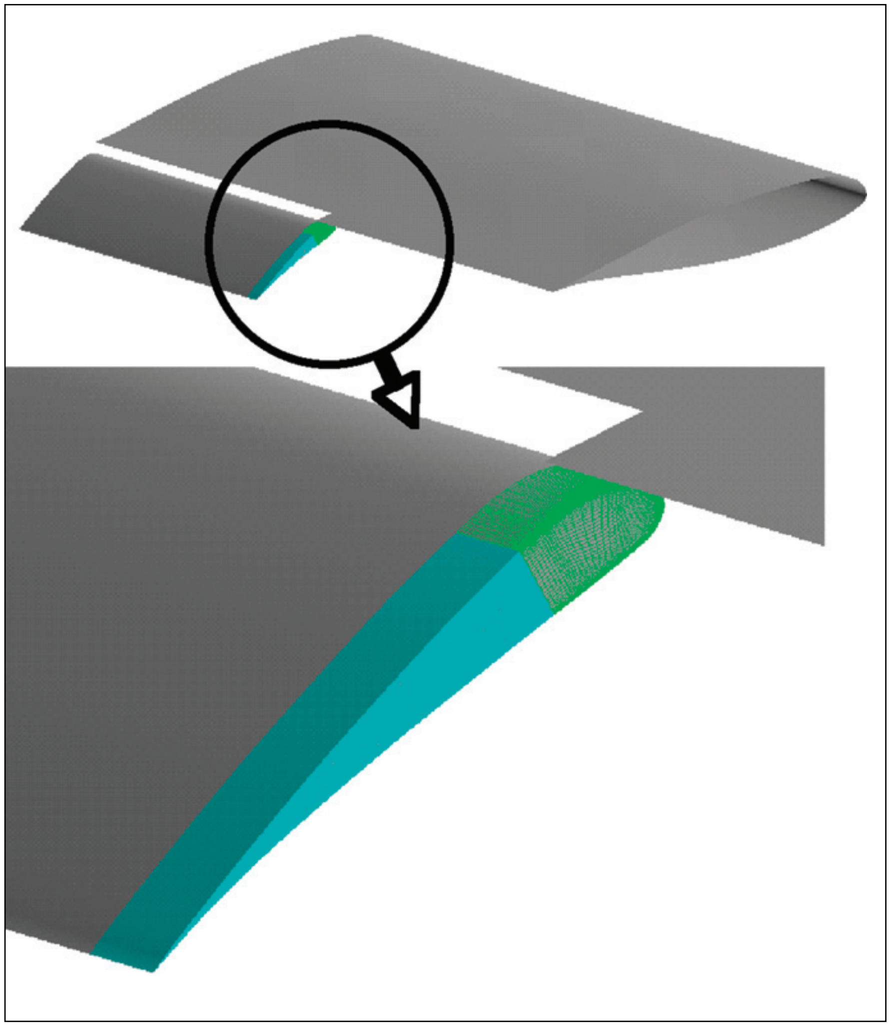
A passive porous treatment has been proposed as a means of suppressing noise generated by the airflow around the side edges of partial-span flaps on airplane wings when the flaps are extended in a high-lift configuration. The treatment proposed here does not incur any aerodynamic penalties and could easily be retrofit to existing airplanes. The treatment could also be applied to reduce noise generated by turbomachinery, including wind turbines. Innovative aspects of the proposed treatment include a minimum treatment area and physics-based procedure for treatment design. The efficacy of the treatment was confirmed during wind-tunnel experiments at NASA Ames, wherein the porous treatment was applied to a minute surface area in the vicinity of a flap edge on a 26-percent model of Boeing 777-200 wing.

The flap side-edge noise constitutes a significant portion of the overall airframe noise during descent and landing of an aircraft. The acoustically relevant flow features at typical flap side edges consist of free shear layers, the roll-up of these layers to form multiple vortices, merging of vortices, and, at high flap deflections, breakdown of these vortices. Because of their unsteadiness and their proximity to flap side-edge surface, these features can contribute to the noise radiated from the flap side edges. To be effective, any treatment for reducing the flap side-edge noise must eliminate, reduce, or alter the vortex initiation regime and the intensity of the vortex roll up and/or breakdown process near the side edge of the flap.

According to the proposal, small, carefully selected areas in the flap-tip regions of each flap would be rendered porous by use of materials similar to those used for wall cooling of turbine blades or the materials used towards acoustical treatment of aircraft-engine ducts (see figure). Porosity at the tips would provide a means of communication between the flow over the lower, side, and upper surfaces near the edge of the flap and, hence, modify the vortex structures near the tip.

Unlike side-edge fences that have been investigated for reduction of flap side-edge noise, the proposed treatment would not incur extra weight and is not likely to accrue drag penalty during the cruise phase of the flight. Unlike the porous tip treatments considered previously in a cut-and-try approach, the proposed porous tip treatment is based on comprehensive analysis of the acoustically relevant features of the flow field and, consequently, would be amenable to optimization. The airflow around the side edges of the flaps can be simulated using computational fluid dynamics (CFD), and results of CFD simulations can be combined with simplified mathematical models of candidate porous treatments to analyze the effectiveness of the treatment in a specific application. Minimization of the amount of area that must be treated in order to reduce the flap side-edge noise to an acceptable degree could be an integral part of the design optimization process.



**Model Geometry and Schematic of Treated Surfaces** are shown. The cyan region depicts the aft-only configuration; the green mesh shows the additional area included in the leading-edge configurations.

*This work was done by Meelan M. Choudhari and Mehdi R. Khorrami of Langley Research Center. Further information is contained in a TSP (see page 1). LAR-16302-1*

# Cylindrical Piezoelectric Fiber Composite Actuators

## Cylindrical actuators offer advantages over flat flexible actuators.

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The use of piezoelectric devices has become widespread since Pierre and Jacques Curie discovered the piezoelectric effect in 1880. Examples of current applications of piezoelectric devices include ultrasonic transducers, micro-positioning devices, buzzers, strain sensors, and clocks. The invention of such lightweight, relatively inexpensive piezoceramic-fiber-composite actuators as macro fiber composite (MFC) actuators has made it possible to obtain strains and displacements greater than those that could be generated by prior actuators based on monolithic piezoceramic sheet materials. MFC actuators are flat, flexible actuators designed for bonding to structures to apply or detect strains. Bonding multiple layers of MFC actuators together could increase force capability, but not strain or displacement capability.

Cylindrical piezoelectric fiber composite (CPFC) actuators have been invented as alternatives to MFC actuators for applications in which greater forces and/or strains or displacements may be required. In essence, a CPFC actuator is an MFC or other piezoceramic fiber composite actuator fabricated in a cylindrical instead of